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Distance between the Left Atrial Appendage and Mitral Annulus Evaluated by CARTO 3 Integrated Computed Tomography Imaging

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Key Words

Atrial fibrillation ablation · Mitral isthmus · Mitral annulus · Left atrial appendage

Abstract

Objective: To measure distances between pulmonary veins (PV) and mitral annulus (MA) using angiographic computed tomography (CT) and to compare them with the left atrial appendage-MA (LAA-MA) line. ***Materials and Methods:*** Data from 46 catheter ablation procedures for atrial fibrillation involving 36 males, mean age 53 years, range 27–78 years, were analyzed. Three types of mitral isthmus lines were measured using angiographic CT images integrated in the CARTO 3 system (Biosense Webster): the distance between the right superior PV and MA (RSPV-MA), the right inferior PV and MA (RIPV-MA), and the left inferior PV and MA (LIPV-MA). They were compared with the length of the LAA-MA line. ***Results:*** The mean value of LIPV-MA was 29 ± 11.2 mm, RIPV-MA 39 ± 8.2 mm, and RSPV-MA 48 ± 8.2 mm. The circumflex artery (CxA) and the coronary sinus (CS) were closest to the LIPV-MA line. Compared with the three isthmus lines, the LAA-MA was the shortest (24.7 ± 15.6 mm), and the difference was statistically significant ($p < 0.05$). ***Conclusion:*** The angiographic CT provided detailed information regarding the anatomy of the left atrium and distances between atrial structures. The LAA-MA was shorter than the other three lines with the CxA and CS situated at a distance.

Introduction

Studies of catheter ablation of persistent atrial fibrillation (AF) had shown that pulmonary vein (PV) isolation alone is associated with a high recurrence rate [1]. By modifying the atrial substrate with creating lines of conduction block inside the left atrium (LA), such as a roof or left lateral mitral isthmus line, had been shown to increase the success rate of persistent AF ablation procedures [2–6]. This could probably be due to the complex anatomy of the mitral isthmus region, but a complete isthmus line could be accomplished in a number of cases [7, 8]. Therefore, creation of a linear lesion at the level of the anterior wall of the LA has been suggested as a means of increasing the success rate of the ablation procedure in patients with persistent AF [9–13].

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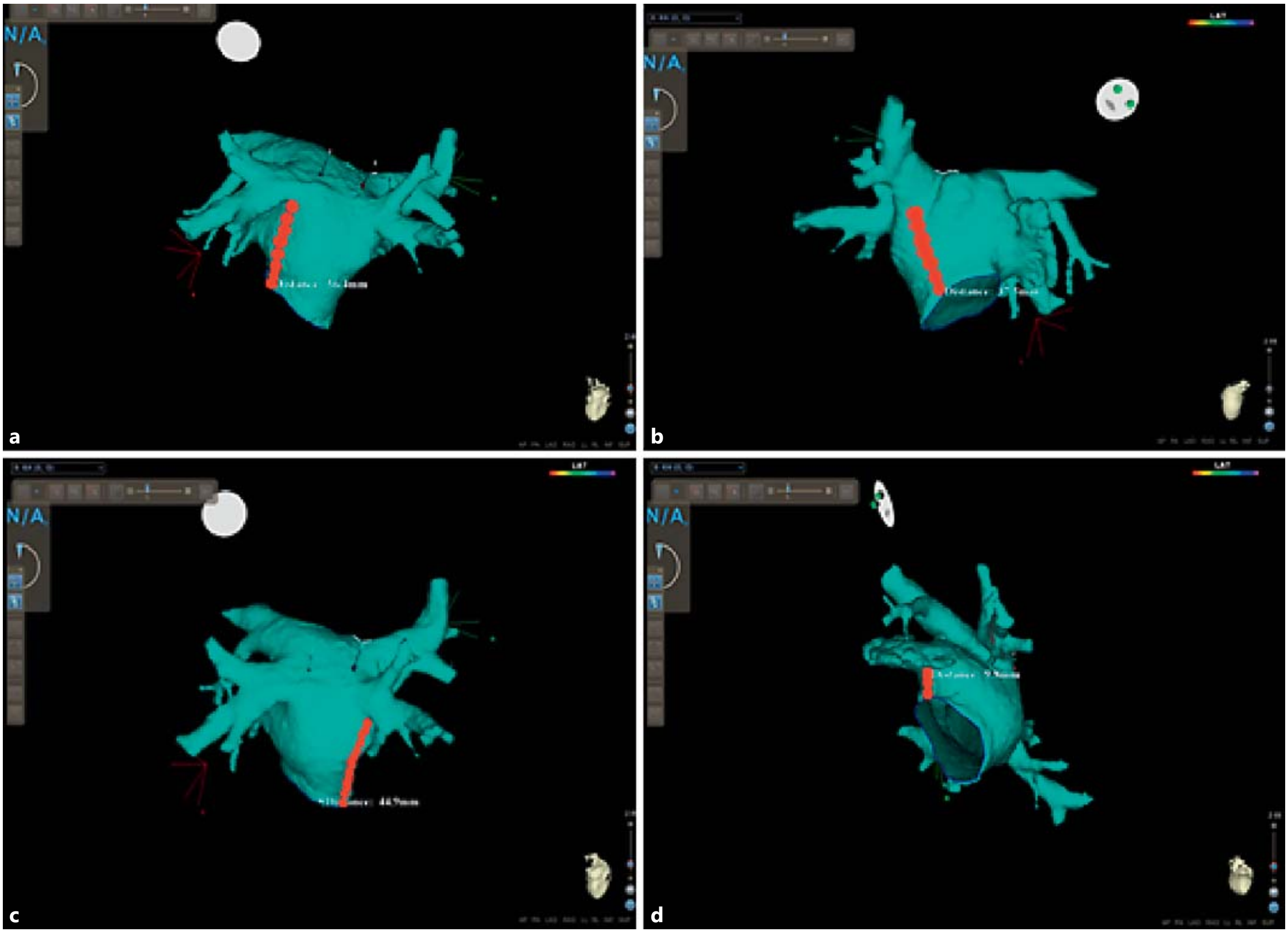

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Fig. 1. CT images integrated with 'Carto viewer' software. **a** Posterior view showing the 'real' mitral isthmus line, the LIPV-MA line. **b** Anterior view: RSPV-MA line. **c** Posterior view: RIPV-MA line. **d** LAO view: LAA-MA line.

The aim of the study was to obtain serial measurements of distances between PV and mitral annulus (MA) using angiographic computed tomography (CT) and to compare them with the left atrial appendage-MA (LAA-MA) line. Creation of a short line, situated at a safe distance from the circumflex artery (CxA), could be of interest in patients with persistent AF ablation.

Materials and Methods

Study Subjects

Cardiac CT data were collected in our institution from 115 consecutive patients, regardless of the referral causes, between January 2012 and July 2014. Of these, 46 consecutive patients (36 males and 10 females), 34 with paroxysmal, 10 with persistent and 2 with permanent AF, underwent a catheter ablation procedure and all of them had a preablation angiographic CT examination of the LA. The mean age of the patients was 53 ± 10.7 years. Treatment before AF ablation consisted of amiodarone in 20 patients, propafenone in 8, flecainide in 6, amiodarone + flecainide in 1, metoprolol in 4 and sotalol in 1. All patients provided written informed consent before the angiographic CT examination and electrophysiological study.

Analysis of CT Images

Angiographic CT images were integrated in the electroanatomical mapping system CARTO 3 (Biosense Webster, Johnson & Johnson, Diamond Bar, Calif., USA) using the 'image integration' software provided by the system. The following distances were measured: the superoinferior diameter, the longest straight line between the roof of the LA and the middle of the MA; the anteroposterior diameter, the longest diameter between the anterior and the posterior wall of the LA, and the laterolateral diameter, the longest diameter between the lateral and the septal wall of the LA. Four types of LA lines were measured: LAA-MA; a line between the inferior margin of the left inferior PV and perpendicular to the MA observed at 4 o'clock in the left anterior oblique (LAO) projection (LIPV-MA); a line between the right inferior PV and the MA at 9 o'clock in the LAO projection (RIPV-MA), and a line between the right superior PV and the MA at 10 o'clock in the LAO projection (RSPV-MA, fig. 1).

Ablation Strategy
The three-dimensional CARTO 3 mapping system was used to guide all ablation procedures. An open-irrigated 7-french 3.5-mm ablation catheter (Navistar Thermocool) was used to create ablation lesions. After LA access was gained through the persistent foramen ovale or transseptal puncture, a circular decapolar mapping catheter was positioned at each PV ostium. The PV isolation was achieved by electrogram mapping-guided ostial ablation. The endpoint of electrical PV isolation was the disappearance or dissociation of PV potentials. In patients with persistent AF, after PV ablation we performed substrate modification with ablation in the LA, right atrium and occasionally inside the coronary sinus (CS) if complex fractionated atrial electrograms were present. The interval confidence level map was also used in a limited number of cases. When AF was converted to an organized atrial tachycardia, its mechanism was explored using an LA activation map.

Statistical Analysis
Data are presented as means ± standard deviation for continuous variables as well as numbers and percentages for categorical variables. The ANOVA test for multiple groups was used to compare continuous variables. The χ^2 test was used for categorical data comparison. SPSS Statistics version 21.0 was used for the statistical analysis and p values less than 0.05 were considered statistically significant.

Results

CT Data for the MA Lines
The measured diameters of the LA were as follows: the longest diameter of the LA was the laterolateral (transverse) diameter, with a mean value of 56.4 ± 7.4 mm; followed by the superoinferior diameter: 51.1 ± 7.3 mm, and the smallest diameter was the anteroposterior diameter, with a mean of 41.4 ± 6.4 mm (table 1). The 'true' mitral isthmus diameter was 29.4 ± 11.2 mm; other isthmic lines measured 39.0 ± 8.2 mm, in the case of the RIPV-MA line and the RSPV-MA 48.2 ± 8.2 mm; the shortest line between LA and a cavitary structure from the LA was the LAA-MA, 24.7 ± 15.6 mm. This line could be of interest for persistent AF catheter ablation procedures, knowing that contact between the ablation catheter with the anterior wall of LAA is not so difficult to achieve.

Representative CT reconstruction images along with the MA lines are presented in figure 1 and morphologic parameters are listed in table 2.

Table 1. Mean values for different diameters and lines inside the LA with standard deviation

SI	51.1±7.3
AP	41.2±6.4
LL	56.4±7.4
LIPV	29.4±11.2
RIPV	39.0±8.2
RSPV	48.2±8.2
LAA	24.7±15.6

SI = Superoinferior diameter; AP = anteroposterior diameter; LL = septolateral diameter; LIPV = LIPV-MA line; RIPV = RIPV-MA line; RSPV = RSPV-MA line; LAA = LAA-MA line.

Table 2. Data of the patients undergoing AF ablation

Mean age, years	53±10.7
Female	9
CHADSVasc score	1 (range 0–3)
Left atrial volume, ml	121.7±56
Ejection fraction, %	56.1±7.3
Type of AF	
Paroxysmal, %	73.9
Persistent, %	21.7
Long-standing persistent, %	4.4
Duration of AF	
Paroxysmal, h	19.5 (range 0.5–72)
Persistent, days	90 (range 1–365)
Long-standing persistent, months	26.5 (range 17–36)
RF applications	67.4±21
RF time, min	52.2±17.4
Procedural time, min	295.7±82

CHADSVasc: score used to calculate stroke risk for patients with atrial fibrillation [C = congestive heart failure; H = hypertension; A = age >75; D = diabetes mellitus; S = stroke/TIA/thromboembolism; V = vascular disease history; a = age 65–74; sc = sex category (female sex)]. RF = Radiofrequency.

Discussion

In this study, the longest LA diameter was the transverse (laterolateral) diameter while the LIPV-MA line was the shortest. Because the LA is bordered anteriorly by the ascending aorta and posteriorly by the esophagus and the vertebral column, the increase in size of the LA is due to an increase in its transverse diameter. The finding that age, sex or weight were not correlated with left atrial diameters is in contrast to other studies that showed correlation between age, sex [14], weight [15], metabolic syndrome [16] or uric acid levels [17] with left atrial function and dimensions. Our study did not show this association, most probably because the patients' number was too small to reach statistical significance.

However, the finding that the LIPV-MA line was the shortest isthmus line between a PV and the MA confirmed that of Cho et al. [18], who compared three different endocardial lines inside the LA. Furthermore, our findings show that the LAA-MA line was shorter than the LIPV-MA line. The anterior wall is more accessible to ablation than the lateral wall at the level of the isthmus [12].

The finding that CT imaging integrated with the CARTO system provided detailed three-dimensional information of the LA was demonstrated by the study of Tops et al. [19] with an average accuracy of 2 mm for the integrated images compared to CT alone and Dong et al. [20] with an accuracy of 1–3 mm. Therefore the same measures evaluated in our study could be obtained directly from CT images. As we perform CARTO integration for all our patients with AF ablation, we measured the values on the reconstructed images.

Clinical Implications

CT is able to provide important information about the LA and LAA anatomy as well as means to measure distances between the LAA and the MA. Using multidetector CT, Cho et al. [18] showed that the CxA and branches of the CS are close to the 'true' mitral isthmus, which could explain the difficulty in obtaining a complete isthmus block due to a washing effect and the possibility of CxA occlusion when ablating at this site. Wittkampf et al. [21] also warned about the proximity of the arterial and venous vessels near the 'true' mitral isthmus, with a mean distance to the CxA of 3.9 ± 2.3 mm. On serial sections, they demonstrated that the major coronary arteries were present on the distal sections more than the proximal ones, thus a proximal ablation line would have a lower risk of arterial damage. Berruezo et al. [22] observed on a series of 4 patients with epicardial transthoracic mitral isthmus ablation that the area of maximum thickness is located above the CS, a region which is impossible to reach from inside the CS. Radiofrequency delivery through transthoracic epicardial approach allowed the creation of bidirectional isthmus block in all patients.

Pak et al. [12] studied the endocardial voltage around the MA in subjects with persistent AF. They found a low-voltage area on the anterior LA wall around the MA, at the LA-aorta contact area (11–12 o'clock on the annulus in the LAO projection). Linear ablation across this low-voltage area was effective in achieving bidirectional block for perimitral reentry.

We postulate that the creation of a line between the MA and left inferior margin of the LAA could be effective in transecting this low-voltage perimitral area. This line would have the advantage of being the shortest line between the MA and another anatomical structure. However, the feasibility and the usefulness of such a line in the treatment of persistent AF have to be established.

The main limitation of this study was that the LAA was not an electrically silent structure. In patients with persistent AF and electrical isolation of the LAA, this line could serve as an electrical barrier when performing an ablation line for perimitral flutter. Another limitation was that of the study size. All the patients come from one center and they are consecutive patients with AF ablation.

Conclusion

Among the four mitral isthmus lines that were measured in this study, the LAA-MA was the shortest. Angiographic CT provided detailed anatomical information for distance measurement. The LAA-MA line could be of interest in persistent AF ablation, but further studies are required to clarify the clinical impact of this finding.

Disclosure Statement

None.

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